Pearson, B.S., V.M.D., M.D., eminent as a veterinarian, scholar and lover of mankind, through whose breadth of vision and untiring efforts these buildings were made possible; whose appreciation of the needs of animal husbandry kept him in sympathetic touch with the farmer, and whose achievements will always be an honor to his alma mater, this tablet is affectionately dedicated by the Guernsey Breeders' Association."

THE will of Mrs. Helen C. Julliard gives $50,000 to the American Museum of Natural History, $25,000 to Colorado College, $100,000 each to St. John's Guild and the Lincoln Hospital, and $50,000 to the New York Orthopedic Hospital.

THE Guggenheim brothers, associated as M. Guggenheim Sons and Co. and in the American Smelting and Refining Company, have added $165,000 to their donations to Mount Sinai Hospital, making their total gifts in memory of their parents $665,000.

ANNOUNCEMENT is made of a gift to the Johns Hopkins Hospital of the sum of $95,000 by Dr. Kenneth Dows, of New York. The money is to be devoted to the investigation of tuberculosis and the better teaching of physicians and students in the recognition and management of the disease and the care of the patients who seek treatment for it at the hospital.

UNIVERSITY AND EDUCATIONAL NEWS

MEMBERS of the Du Pont family, who are alumni of the Massachusetts Institute of Technology, have given $800,000 for the extension and maintenance of the new buildings. Four other alumni—Charles Hayden, C. A. Stone, E. A. Webster and Edward B. Adams—have subscribed sums amounting to $200,000. It is understood that the anonymous donor who has already made large gifts to the institute has undertaken to give five dollars for each three dollars subscribed by the alumni during the present year.

IT is planned to hold the annual meeting of the American Association of University Professors in New York City on Friday and Saturday, December 30 and 31. Further details will be published in the October number of the *Bulletin* of the association.

DR. WALTER EUGENE GARREY, for some time connected with the department of physiology of the Washington University, St. Louis, Missouri, has been elected to the chair of physiology in the college of medicine of Tulane University of Louisiana.

PROFESSOR JAMES F. NORRIS, head of the department of chemistry at Vanderbilt University, Nashville, Tenn., has resigned to accept a professorship of general chemistry at the Massachusetts Institute of Technology. He will be immediately associated with the instruction to be given in the fourth and fifth years of the new course in chemical engineering just established. Professor Frank H. Thorp, of the institute, has resigned his assistant professorship of industrial chemistry, and expects to devote himself in the immediate future to private business.

DR. ROSS AIKEN GORTNER, from 1909 to 1914, resident investigator in biological chemistry at the Station for Experimental Evolution of the Carnegie Institution and since that time associate professor of soil chemistry in the division of soils of the University of Minnesota, will transfer, on August 1, to the division of agricultural bio-chemistry in the same institution, with the title of associate professor of agricultural bio-chemistry, in charge of the section of bio-chemical research.

LESLIE ALVA KENOYER, Ph.D. in botany from the University of Chicago, has been appointed to a professorship in biology at Ewing Christian College, Allahabad, India, and is sailing from Vancouver on June 29.

DISCUSSION AND CORRESPONDENCE

THE ACCEPTED FACTS OF DYNAMICS

OF those who have contributed to the recent discussion in SCIENCE concerning the methods of presenting the laws of dynamics, all would

undoubtedly solve actual problems with accordant results. If this is true it is evident that the disagreement is largely a matter of words rather than of principles, and that if all understood one another a large part of the apparent disagreement would vanish. Most of us find it difficult to give the same careful consideration to propositions advanced by others that we expect them to give to our own. The habitual use of a certain routine tends to give the mind a "permanent set" which makes it difficult to appreciate the fact that equal familiarity might prove another routine to be equally effective. One who is strenuously opposed to a particular method will find it a useful exercise to adopt that method temporarily and apply it to actual problems in sufficient number and variety to make him thoroughly familiar with it.

I have not the slightest doubt that the routine favored by Mr. Kent[1] can be used effectively in teaching students to state correctly the solutions of problems in uniformly accelerated motion. Neither have I any doubt that the method outlined by me[2] can be used with equal effect. In the explanation of the fundamental equation the two methods are in fact identical, except as regards the matter of the choice of units. Mr. Kent apparently believes that the adoption of a particular set of units[3] is essential to the success of his method, while I believe it to be important to emphasize the fact that the choice of units is arbitrary and that Mr. Kent's units are no more easily understood than other systems which are in common use. To define units so that *unit force would give unit quantity of matter an acceleration of 1 foot per second per second* seems to me to be as simple and as easily understood as the definition *unit force is the force which would give unit quantity of matter an acceleration of 32.1740 feet per second per second.* The two definitions are based upon the same fundamental principle, and it would seem that a very effective method of helping the student to grasp the real significance of this principle is to give him plenty of practise in applying both definitions and in reducing forces and quantities of matter from one unit to another.

The chief remaining difference between Mr. Kent and myself is a verbal one: It seems to me undesirable (because obstructive of clear thinking) to designate two distinct physical quantities such as "quantity of matter" and "earth-pull" by the same name when there is an easy way to avoid it; but I have no expectation of converting Mr. Kent to my opinion on this point.

The method advocated by Professor Huntington can also without doubt be made effective if used with due persistence by an enthusiastic teacher like himself. The peculiar feature of this method is that it purports to be independent of mass. The eleven propositions which embody the latest presentation of the method[4] are in fact free from any adequate explanation of mass; but until the omission is supplied the sufficiency of these propositions can not be granted. The question of their sufficiency may be put to a simple test: Do they suffice for the solution of problems like the following:

A certain body has an acceleration of 10 ft./sec.^{2} when acted upon by a force F, and a second body has an acceleration of 15 ft./sec.^{2} when acted upon by an equal force F; if the two are combined into a single body, what acceleration will this body have if acted upon by a force F?[5]

[1] Science, December 24, 1915.

[2] Science, April 23, 1915, p. 609.

[3] Mr. Kent refers to the "good old principle, Unit force (pound) acting on unit mass (1 pound) gives it an acceleration of 32.1740 feet per second." As a matter of fact the antiquity of this "principle" is considerably less than that of the poundal (it was only in 1901 that the value 32.1740 feet per second per second was adopted by the International Conference of Weights and Measures as the most probable value of g at sea-level in latitude 45°); moreover it may be doubted whether this unit force has ever been employed practically. The really "good old" unit force is the weight of a pound mass (or kilogram mass) wherever the observer happens to be; this is still, and doubtless will continue to be, the unit employed in most practical applications.

[4] Science, March 3, 1916.

[5] The problem might be generalized as follows: A certain body has the acceleration a' when acted

The solution of such problems involves the use of a principle equivalent to the following: *The mass of a body is equal to the sum of the masses of the individual portions of matter composing it.* Professor Huntington doubtless accepts this principle (even if disapproving the language in which it is expressed); but nothing equivalent to it seems to be either expressed or implied in the eleven propositions given by him as sufficient. It is not merely that the word "mass" is not used; the term "standard weight" which replaces it is not defined or explained in such a way as to cover the above principle; there is no intimation that standard weight is the measure of an *additive property*[6] of matter—that *the standard weight of a body is the sum of the standard weights of its parts.*[7] But if this is not an

upon by the force F', and a second body has the acceleration a'' when acted upon by the force F''; a body formed by combining the two would have what acceleration when acted upon by a force F? For example, the addition of 1,000 tons to the load carried by a 5,000-ton vessel would have what effect upon the acceleration of the vessel when starting from rest with a given propeller action?

[6] Of additive properties which are invariable and possessed by *all* matter there are two: *inertia* and *gravitation*. These furnish two independent methods of making exact quantitative comparisons of different portions of matter. It is believed to be a fact that the two methods give results in exact agreement, but the basis of this belief is, and must be, precise experiment, as was explicitly recognized by Newton (although Mr. Kent apparently expects boys to learn it by watching the grocer weigh sugar). Comparing quantities of matter by weighing would involve only the property of gravitation if the earth were at rest; because of the earth's rotation it involves also the property of inertia. (The word inertia is here used in a quantitative sense for lack of a less objectionable term.)

[7] Proposition 9 includes the statement that standard weight is "characteristic of the given body," and proposition 3 the statement that "if any material is added to or taken away from the body it ceases to be the same body"; but there is no intimation that the addition of matter to a body may not produce a body of less standard weight than the original body.

essential part of the principles of dynamics as actually interpreted in solving problems, I would be glad to know how it can be dispensed with in the case of the particular problem stated above.

The point which Professor Huntington's method of statement evades is brought out clearly also by the following citations from former articles in SCIENCE:

Professor Huntington's view:[8] The statement: "Body A has three times the mass of body B" is precisely equivalent to the statement: "Body A requires three times as much force as body B to give it a specified acceleration."

Ordinary view as understood by me:[9] The statement that "body A has three times the mass of body B" means more than that "body A requires three times as much force as body B to give it a specified acceleration"; it means that the material contained in body A might be made into three bodies, each of which would require the same force as body B to give it a specified acceleration.

If the latter view is correct, it shows clearly the appropriateness of the words "quantity of matter" as a brief definition of mass.[10] If it is not correct, I would again ask how it is possible to solve problems such as the one given above.

If a proposition expressing the fact that the standard weight of a body is equal to the sum of the standard weights of its parts is added to Professor Huntington's eleven numbered statements, the scheme becomes indeed logically "sufficient" as an explanation of the fundamental equation of motion. It is also, of course, logically redundant, all that part referring to gravity being irrelevant as regards the real meaning of the laws of dynamics. This redundancy is not necessarily objectionable

[8] SCIENCE, July 30, 1915, p. 159.

[9] SCIENCE, September 10, 1915, p. 341.

[10] The significance of the words quantity of matter in dynamics was discussed in a former communication (SCIENCE, September 10, 1915). A fuller analysis is given in an article published in the *American Mathematical Monthly*, February, 1916.

in a preliminary explanation, but the fact should finally be made clear that the second law of motion is quite independent of the law of gravitation and of the facts of terrestrial gravity. The fact that the word weight is usually associated with gravity makes the term "standard weight" misleading and inappropriate as the name of a "characteristic of the given body" which has nothing to do with gravity.[11]

Full comment on the latest communications of Mr. Kent and Professor Huntington would consist largely of the repetition of comments made in previous communications by myself and others, and I shall take space only for a remark regarding their attitude toward the equation $F = ma$. They agree in objecting most strenuously to the use of this equation. The grounds of the objection as stated by Professor Huntington are that it implies "a perfectly arbitrary choice of units" and a choice that is "needlessly complicated and quite unscientific." When these objections are considered in connection with the units endorsed by both Mr. Kent and Professor Huntington, the implication seems to be that it is less arbitrary, less complicated and more scientific to define a unit force as "the force which would give the unit mass 32.1740 units of acceleration" than as "the force which would give the unit mass one unit of acceleration." What reason there is for such a supposition it is not easy to see.

The fact that the choice of units is always arbitrary is indeed a very important fact to emphasize with students, and probably the only way to do this effectively is to give practise in the use of different sets of units in solving the same problems. If any author states or implies that the unit force *must* be defined as the force which would give unit mass unit acceleration, he makes an unfortunate mistake; but the same may be said of one who states or implies that the force which would give a unit mass 32.1740 units of acceleration is other than an arbitrarily chosen unit.

[11] This inappropriateness is strikingly apparent in referring to astronomical masses. In a recent lecture by an astronomer of high reputation the statement was made that the sun contains more than 97 per cent. of the matter in the solar system. How would this fact be expressed by Professor Huntington? Would he speak of the "standard weights" of the sun and the solar system?

L. M. Hoskins

Stanford University,
April 8, 1916

ELECTRICAL ACTION AND THE GRAVITATION CONSTANT

In Science for December 31 Professor Nipher suggests that previous determinations of the gravitation constant may be in error, owing to the force action of electric charges on the attracting masses. The point is interesting, but in estimating the possible magnitude of the effect the author seems to have committed a serious error.

He puts the charge Q on a sphere equal to RV, where R is the radius and V is the *absolute* potential of the sphere. But this equation holds only when the sphere is alone in space; otherwise it may be nowhere near true. Consider, for instance, an insulated uncharged sphere inside a closed metal box. By charging up the box we may change the absolute potential of the sphere by a large amount without placing any charge whatever upon the sphere itself.

If Professor Nipher really has made this slip, he is at least in august company. For no less an authority than Boltzmann fell into a similar error, when he set the capacity of a conducting molecule *between two conducting plates* equal to its radius.[1]

In the classical experiments on the gravitation constant charges certainly existed on the attracting masses, in consequence of contact potentials between metals if for no other reason. But Professor Nipher's calculation indicates a possible error due to contact potentials of only a per cent. or two. Furthermore, the electric effect would be enormously influenced by the nature and arrangement of other parts of the apparatus, and these have varied widely. It seems doubtful, therefore, whether the actual error due to this cause can exceed the very

[1] Gastheorie, I., p. 79.